

## Book Review

### The Behavior of the Earth; Continental and Seafloor Mobility by Claude Allègre

The modern theory of continental drift, plate tectonics, sea floor spreading, global tectonics and polar wander can be expressed as follows:

The results of geophysical research over the past two decades have left little doubt that subcrustal convection currents exist, driven by temperature differences in the mantle. Isotacy would be impossible without such currents. The outer layers surrounding the Pacific basin have been displaced toward its center, relative to the deeper layers, causing the Pacific basin to shrink in size. Earthquakes, both deep and shallow, repeatedly break in the same direction showing that continental block move as a whole - a motion which can be a rotation, a translation or both. A global stress pattern results as the outer layer moves over a spheroidal Earth. Convection, continental drift and polar wander go hand in hand.

Subcrustal currents exert tension on large continental assemblages which break up, and the pieces move to the sites of downwellings. Mountains form on the leading edges of the continents where the currents are descending and new ocean floor develops at the gap where currents are ascending. The obstruction that stands in the way of continental advance is the oceanic basaltic layer, and for advance to be possible the basaltic rocks must be continuously moved out of the way. In other words, they must founder into the depths, since there can be nowhere else for them to go. The expression of such a down-turning of the basaltic layer is an oceanic deep (trench) which forms where old oceanic crust once existed. At great depth the basalt converts to dense eclogite and gradually sinks out of the way, providing room for the crust on either side to be drawn inwards by the horizontal currents beneath them.

The eclogite that founders into the depths will gradually be heated up as it shares in the convective circulation. Eventually it begins to melt and rises again to the top. These basaltic magmas form plateau basalts on continents and islands in the middle of oceans. Most of the basaltic magma, however, rises with the ascending currents of the main convectional system to form new oceanic crust. New oceanic crust is formed at a globe encircling oceanic ridge system which can be traced by continuous seismic activity. Thus, in a general way, it is possible to understand how the gaps rent in the crust come to be healed again; and healed moreover with exactly the right sort of material to restore the basaltic layer. To sum up, during large scale convective circulation the oceanic basaltic layer becomes a kind of endless travelling belt on the top of which a continent can be carried along, until it comes to rest (relative to the belt) when its advancing front reaches the place where the belt turns downwards and disappears into the Earth. The oceanic crust is carried back into the mantle but the buoyant continents remain at the surface and collect over mantle downwellings. Convection currents in a heated sphere with Earth-like characteristics are calculated to move at a centimeter per year. This is about the rate that giant transcurrent faults slip and the rate of continental drift from paleomagnetic data. Prior to about 200 million years ago there were only a few giant land masses. Where they were joined can be told by matching up the geology and biology. Large shifts of the continents are also inferred from glaciations and other climatic indicators.

The lithosphere is the strong outer shell of the Earth and lies over a weaker asthenosphere which is hot, flows readily and is probably partially molten and the source of magma. When it dives back into the mantle it generates deep focus earthquakes and deep oceanic trenches.

This was all text book knowledge in the 1940's and 1950's. In fact, the above is extracted from Holmes' "Principles of Physical Geology" (1945), Gutenberg's "Physics of the Earth's Interior" (1957) and "Internal Constitution of the Earth" (1951) and Heiskanen and Vening Meinesz "The Earth and its Gravity Field," (1958).

These authors were among the most influential Earth scientists of the first half of this century. The fact that they received many honors indicates that they were not ignored by their colleagues. Was the much heralded "plate tectonic revolution" nothing more than an affirmation of the theories of Wegner, Holmes, Gutenberg, Heiskanen, Vening Meinesz and Pakeris and many others? If the giants of the 40's and 50's believed in seafloor and continental mobility, global tectonic patterns and polar wander why are they not considered the founders of plate tectonics? This book attempts to explain why.

The synthesis at the beginning of this review, from references more than 30 years old, is more advanced in many ways than current views of how the Earth works. True polar wander then was an accepted consequence of mantle convection. Until very recently polar wander has been treated as "apparent polar wander" due to continental drift over a planet with fixed poles. Petrology and geochemistry are still trying to fit themselves into plate tectonics. Holmes (1945) had a complete, self-consistent scheme of generating magmas from a basalt/eclogite rich source region which formed new oceanic crust, and continental basalts, with the oceanic crust recycling back into the mantle to be used again. Present day petrologists and geochemists tend to talk of "primitive" mantle, multiple source regions for oceanic and continental basalts and complete remixing of subducted basalts back into a peridotitic,

basalt-poor, source region. Mountain belts were treated as deformation at the leading edge of a continent running into oceanic lithosphere or into another continent; plate tectonics assumes rigid plates. If too much deformation or polar wander is accepted the basis of "rigid plate tectonics" disappears.

The start of the seafloor spreading revolution is generally given the date of 1960 with victory proclaimed when plate tectonics came on board about 1967. This was an intense, competitive and traumatic time in Earth science. A new generation with new techniques was moving in and a marine and global perspective was overwhelming continental and "quadrangle" geology. The history books are now starting to appear, written by some of the participants and their friends. The book by Claude Allègre, translated from the French, is the latest entry in the scientific hindsight and recollection sweepstakes. A book by Bill Menard (The Ocean of Truth), a more direct participant, appeared several years ago. Menard's book, in particular, will be useful to future historians since he tried to check his recollections with others and it appears to be accurate even if limited by his own perspectives and emphasis on his own specialties and colleagues. This is always a problem with histories of science written by the participating scientists.

Claude Allègre is a much younger scientist and has a different circle of friends, many of whom were active soldiers in the revolution. His history is more gossipy and second hand and is unencumbered by references to original scientific papers. It is also a book about the politics and philosophy of science, as is Menard's. Allègre is one of the most creative and wide-ranging Earth scientists and is a master of exposition and synthesis. It is here where the book comes into its own. It is best to view this book as an excellent elementary text on how the Earth behaves, leavened by little stories on

personalities and interactions of scientists during an exciting time in Earth science. It can be read easily by the layman and the undergraduate.

Don L. Anderson